

CLAIMS

What is claimed is:

1. A method in a digitally convertible radio (DCR) for optimizing a signal-to-noise ratio (SNR) in a multi-port system, the method comprising:

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receiving a plurality of input digital data streams, the digital data of the input data streams further having magnitude and phase components wherein the plurality is equal to “N” input digital data streams;

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creating a corresponding plurality of mixed input data streams from the plurality of input data streams and a plurality of weighted vector values, each of the plurality of mixed input data streams including magnitude and phase components of all the plurality of input data streams wherein the corresponding plurality is equal to “N”;

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converting the plurality of mixed input data streams to a plurality of analog mixed signals;

amplifying the plurality of analog mixed signals;

producing, in an analog hybrid matrix, a plurality of sector signals from the plurality of amplified

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analog mixed signals, respectively, wherein:

the first sector signal comprising a maximum first sector signal, a minimal second sector signal component, and a minimal third sector signal component;

the second sector signal comprising a maximum second sector signal, a minimal first sector signal component, and a minimal third sector signal component; and

5 the third sector signal comprising a maximum third sector signal, a minimal first sector signal component, a minimal second sector signal component;

transmitting the first, second, and third sector signals from antennas coupled to a first output port, a second output port, and a third output port, respectively;

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correlating digital domain representations of the first, second, and third sector signals with the plurality of input data streams to produce a plurality of sector cross-correlated signals;

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correlating the plurality of input data streams with each other to produce a plurality of input cross-correlated signals;

substantially canceling the cross-correlation between input data streams present in the plurality of sector cross-correlated signals to produce a plurality of corrected sector cross-correlated signals, wherein:

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the step of substantially canceling the cross-correlation substantially removes, from a single sector cross-correlated signal, the correlated components of all other sector cross-correlated signals;

producing normalized power feedback signals from the plurality of corrected sector cross-correlated signals; and

5 determining, from the normalized power feedback signals, a plurality of weighted vector values.

2. The method of claim 1 wherein the step of producing the plurality of sector signals further includes compensating for analog phase and amplitude errors introduced by the steps of  
10 converting and amplifying by introducing weighted vector values having magnitude and phase components that substantially corrects for the introduced phase and amplitude errors.

3. The method of claim 1 wherein the digital domain representations of the plurality of sector signals are produced from an analog-to-digital converter prior to the step of correlating the  
15 digital domain representations of the plurality of sector signals with the plurality of input data streams.

4. The method of claim 1 further including coupling the plurality of sector cross-correlated signals and the plurality of input cross-correlated signals to a cancellation module, the  
20 cancellation module for mixing the input cross-correlated signals with certain sector cross-correlated signals and then subtracting this from the sector cross-correlated signals and thereby producing a plurality of corrected sector cross-correlated signals.

5. The method of claim 4 wherein the step of determining the normalized power feedback signals levels further includes minimizing an undesired power level by sequentially and iteratively searching for a minimum undesired power level by adding and then subtracting an increment to the weights to cause a decrease in undesired output power level.

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6. The method of claim 1 wherein the step of creating the plurality of mixed input data streams further includes:

mixing each of the plurality of input data streams with a plurality of weighted vector values to  
10 create a plurality of weighted input data streams wherein “N” weighted input data streams are created from each of the plurality of input data streams and further wherein the plurality of weighted input data streams is equal to  $N^2$ ;

summing a first weighted input data stream created from a first input data stream, a first  
15 weighted input data stream created from a second input data stream, and a first weighted input data stream created from a third input data stream to produce a first mixed input data stream;

summing a second weighted input data stream created from the first input data stream, a second weighted input data stream created from the second input data stream, and a second weighted  
20 input data stream created from the third input data stream to produce a second mixed input data stream; and

summing a third weighted input data stream created from the first input data stream, a third weighted input data stream created from the second input data stream, and a third weighted input data stream created from the third input data stream to produce a third mixed input data stream.

7. A digital convertible radio comprising:

a digital hybrid matrix (DHM) for producing a plurality of mixed input data streams from a plurality of input digital data streams and a plurality of weighted vector values, wherein each of  
5 the plurality of mixed input data streams includes magnitude and phase components from each of the plurality of input data streams;

an up-conversion module operably coupled to receive the plurality of mixed input data streams from the DHM, the up-conversion module for converting the plurality of mixed input data  
10 streams from a digital domain to an analog domain and for up-converting the analog domain signals to a radio frequency (RF) to produce a plurality of analog RF mixed signals;

an amplifier module further including a plurality of amplifiers for receiving and amplifying the plurality of analog RF mixed signals;

15 an  $N \times N$  analog hybrid matrix (AHM) coupled to receive the  $N$  amplified analog RF mixed signals, the AHM for producing  $M$  sector signals, wherein  $M$  is equal to or less than  $N$ , and wherein each sector signal, of the  $M$  sector signals, comprises a maximum component of that sector signal and minimal components of all other sector signals;

20 a plurality of transmitting antennas for transmitting the  $M$  sector signals received from the  $N \times N$  analog hybrid matrix;

a down-conversion module operably coupled to receive the M sector signals from the AHM, the down-conversion module for:

converting the M sector signals from the analog domain to the digital domain to produce  
5 M converted sector signals, wherein the M converted sector signals are digital domain representations of the M sector signals; and

down-converting the digital domain signals to a baseband frequency;

10 a correlation module for producing a  $N^2$  sector cross-correlated signals and  $2*N$  input cross-correlated signals from the received M converted sector signals, and from the N received input data streams;

a cancellation module operably coupled to receive  $M^2$  sector cross-correlated signals and  $2*N$   
15 input cross-correlated signals and to produce  $M^2$  corrected sector cross-correlated signals;

a power determination module operably coupled to receive the  $M^2$  corrected sector cross-correlated signals, the power determination module for producing a plurality of normalized power feedback signals from the received  $M^2$  corrected sector cross-correlated signals; and

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a weighted vector adjustment module operably coupled to receive the plurality of normalized power feedback signals, the weighted vector adjustment module further producing a plurality of weighted vector values, wherein the plurality of weighted vector values function to minimize undesired signal components in the plurality of sector signals.

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8. The digital convertible radio of claim 7 wherein the up-conversion module further includes:

digital signal processing circuitry for manipulating digital data of the mixed input data streams in  
10 the digital domain; and

digital-to-analog circuitry for converting the mixed input data streams from the digital domain to the analog domain.

15 9. The digital convertible radio of claim 7 wherein the down-conversion module further includes analog-to digital circuitry for converting the plurality of sector signals from the analog domain to the digital domain;

10. The digital convertible radio of claim 7 wherein the weighted vector adjustment module  
20 further includes:

a digital processor, comprising one of a microprocessor, microcontroller, application specific integrated circuit (ASIC), or field programmable gate array (FPGA), or other processor, the digital processor for:

5 storing and executing computer instructions that define operational logic of the weighted vector adjustment module;

receiving and processing the plurality of normalized power feedback signals; and

10 generating the plurality of weighted vector values;

a bus coupled to the digital processor for transmitting computer instructions and control signals to and from the digital processor within the weighted vector adjustment module;

15 memory coupled to the bus, the memory for storing data; and

an input/output module for receiving the plurality of normalized power feedback signals and for coupling the plurality of weighted vector values to the DHM.

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11. The digital convertible radio of claim 10 wherein the digital processor further includes logic for optimizing the plurality of weighted vector values, wherein:

for each magnitude and phase component of each of the plurality of weighted vector values, the  
5 digital convertible radio measures a first undesired signal power level resulting from subtracting  
a first increment from each of the weighted vector values;

for each magnitude and phase component of each of the plurality of weighted vector values, the  
digital convertible radio measures a second undesired signal power level resulting from adding a  
10 second increment to each of the weighted vector values; and

wherein the digital convertible radio adjusts each magnitude and phase component of the  
weighted vector value with one of the first increment or second increment that results in the  
lowest undesired signal power level.

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12. The digital convertible radio of claim 11 wherein the first and second increments  
comprises one of an equal magnitude or an unequal magnitude.

13. The digital convertible radio of claim 11 wherein the first and second increments are a

20 fixed magnitude.

14. The digital convertible radio of claim 11 wherein the first and second increments have a variable magnitude, wherein the variable magnitude changes based on digital convertible radio metrics.

5 15. The digital convertible radio of claim 1 wherein the digital hybrid matrix further includes:

a plurality of complex multipliers, each complex multiplier operably coupled to receive one of the plurality of weighted vector values, and further coupled to receive one of the plurality of  
10 input data streams and to produce therefrom a plurality of weighted input data streams;

a plurality of summation units operably coupled to receive the plurality of weighted input data streams and produce therefrom a plurality of mixed input data streams; and

15 wherein each of the mixed input data streams includes magnitude and phase components of each of the plurality of input data streams.

16. The digital convertible radio of claim 1 wherein the analog hybrid matrix separates based on the weight values in the DHM the analog components of the amplified analog mixed signals  
20 into a plurality of sector signals for transmission to a corresponding sector antenna.

17. A weighted vector adjustment module of a digital convertible radio, comprising:

a digital processor for storing and executing computer instructions that define operational logic for processing the plurality of normalized power feedback signals, the digital processor further including computer instructions that define logic for generating the plurality of weighted vector values.

a bus coupled to the digital processor for transmitting signals to and from the digital processor within the weighted vector adjustment module;

an input/output module coupled to the bus, the input/output module for receiving the plurality of normalized power feedback signals from the power determination module and for coupling the plurality of weighted vector values to a digital hybrid matrix (DHM); and

memory coupled to the bus, the memory for storing data.

18. The digital convertible radio of claim 17 wherein the digital processor further includes logic for optimizing the plurality of weighted vector values, and wherein:

for each magnitude and phase component of each of the plurality of weighted vector values, the  
5 digital convertible radio measures a first undesired signal power level resulting from adding a first increment to each of the weighted vector values;

for each magnitude and phase component of each of the plurality of weighted vector values, the  
digital convertible radio measures a second undesired signal power level resulting from  
10 subtracting a second increment to each of the weighted vector values; and

wherein the weighted vector adjustment module adjusts each magnitude and phase component of the weighted vector values with one of the first increment or second increment that results in the lowest undesired signal power level at the sector ports.

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19. The digital convertible radio of claim 17 wherein the first and second increments are one of an equal magnitude or an unequal magnitude.

20. The digital convertible radio of claim 19 wherein the first and second increments have  
20 one of a fixed or a variable magnitude, wherein the variable magnitude changes based on digital convertible radio metrics.

21. An undesired signal minimization method in a digital convertible radio, the method comprising:

generating a plurality of weighted vector values, wherein each weighted vector value comprises a  
5 magnitude and phase component;

responsive to the plurality of weighted vector values, receiving a plurality of normalized power  
feedback signals, wherein each of the plurality of normalized power feedback signals includes  
desired signal power measurements and undesired signal power measurements;

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for each magnitude and phase component of each of the plurality of weighted vector values,  
receive a first undesired signal power level resulting from subtracting a first increment from each  
of the magnitude and phase components of the weighted vector values;

15 for each magnitude and phase component of each of the plurality of weighted vector values,  
receive a second undesired signal power level resulting from adding a second increment to each  
of the magnitude and phase components of the weighted vector values; and

adjusting each magnitude and phase component of the weighted vector values with one of the  
20 first increment or second increment based on the increment that results in the lowest undesired  
signal power level.

22. The method of claim 21 wherein the first and second increments are one of an equal magnitude or an unequal magnitude.

23. The method of claim 21 wherein the first and second increments have one of a fixed or a  
5 variable magnitude, wherein the variable magnitude changes based on digital convertible radio metrics.